Clinical Medicine

Prevalence of Coronary Heart Disease Risk Factors in a Young Military Population

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REPORT NO. M 3/80

PATTON, J. F., and J. A. VOGEL. *Prevalence of coronary heart disease risk factors in a young military population.* Aviat. Space Environ. Med. 51(5)510-514, 1980.

This study was undertaken to determine the extent to which coronary heart disease risk factors are manifest in a young (17-35 years old) male military population. Approximately 360 individuals underwent medical and physical determination of body composition, blood cholesterol analysis, blood pressure measurement, history of smoking, and a maximal exercise stress test to assess maximal oxygen uptake ($\dot{V}O_2max$) and the incidence of electrocardiographic abnormalities. Obesity (>20% body fat), elevated blood cholesterol (>200 mg/dl), and cigarette smoking (>10 cigarettes/d) were the most predominant risk factors with incidences of 29, 32, and 36%, respectively. Only 2.4% of the sample had a positive stress test as indicated by an ST-segment depression of 1 mm or greater. An inverse relationship between $\dot{V}O_2max$ and percent body fat was the only significant finding between level of aerobic power and risk factor prevalence. These data provide information on the prevalence of cardiovascular disease risk factors in an age group for which there has been only limited information.

OVER THE PAST 15-20 YEARS, a number of studies (5,18,19,35) have identified factors which place an individual at increased risk for the development of coronary heart disease (CHD). These factors include hypertension, elevated blood lipids, cigarette smoking, diabetes mellitus, obesity, anxiety and tension, electrocardiographic abnormalities, family history of heart disease, and lack of physical activity.

While the identification of these factors has been heavily stressed for the adult population over 35 years of age, it has recently become apparent that they are identifiable during adolescence or even early childhood (13,37). Enos *et al.* (11) demonstrated that 70% of autopsied Korean war casualties who averaged 22.1 years of age had at least moderately advanced CHD. More recently McNamara *et al.* (26) found evidence of CHD in 45% of Vietnam War casualties. The studies of Mason (25) and Rigal *et al.* (33) on young men have produced similar results.

The primary objective of the present study was to identify the extent to which some of the CHD risk factors are manifest in a population of young (17 - 35 years of age) male military personnel.

MATERIALS AND METHODS

There were 360 men between the ages of 17 and 35 randomly selected from a computer printout of personnel assigned to a U.S. Army Infantry Division for participation on a voluntary basis in the study.

Each subject completed a personal history questionnaire and underwent a physical examination. Supine systolic and diastolic blood pressures were measured to the nearest 2 torr using a mercury sphygmomanometer. A resting 12-lead electrocardiogram (ECG) was obtained using disposable ECG skin electrodes and a model 1500 Hewlett-Packard electrocardiograph. A 10 cm^3 blood sample was taken from the antecubital vein for plasma cholesterol determination using the procedure of Leffler and McDougald (24). Subjects were grouped as smokers ($\geq$ 10 cigarettes/d) or nonsmokers. No attempt was made to record the length of time since the start of smoking or whether nonsmokers had ever smoked.

In approximately 320 subjects, body weight (kg) and height (cm) were determined and skin-fold thicknesses (mm) measured at the subscapular, triceps, biceps, and suprailiac sites for estimation of body fat using Harpenden skinfold calipers. Appropriate regression equations for men were used to estimate percent body fat from the sum of the skinfold thicknesses (14).

There were 300 subjects who consented to participate in a maximal exercise capacity test. This consisted of an interrupted treadmill running test for the determination of maximal oxygen uptake ($\dot{V}O_{2max}$) using the procedure described by Taylor *et al.* (34) and modified by Mitchell *et al.* (27). Following an initial familiarization period on the treadmill, each subject performed a submaximal run at an absolute exercise intensity of 6 m.p.h., 0% grade, for 6 min. This was followed by 2-4 interrupted runs of 3-4 min duration at 6 or 7 m.p.h. with the grade being raised in increments of 2.5% until a plateau occurred in oxygen uptake with increasing intensity. A 5-10 min rest period was allowed between runs.

Expired air was collected in Douglas bags during the final min of each run and oxygen and carbon dioxide concentrations determined using Beckman E-2 and LB-

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1 gas analyzers, respectively. Expired air volumes were measured with a Collins chain-compensated gasometer. Submaximal and maximal values were calculated for minute ventilation ($\dot{V}_{E_{BTPS}}$) and oxygen uptake ($\dot{V}O_2$). During the treadmill test, precordial lead V_5 of the ECG was monitored continuously and recorded during the final minute of each run. At 2, 4, and 6 min following the exercise intensity that elicited a $\dot{V}O_{2max}$, the ECG was again recorded for evaluation of ST-segment changes. The criterion used for a positive stress test was an ST-segment depression $\geq$ 1 mm that persisted for at least 80 ms after the end of the QRS complex (1).

A one-way analysis of variance was used to test the significance of the difference between age group means. Chi-square analysis was used to determine significance in the frequency of variables between age groups. The relationship between various risk factors and $\dot{V}O_{2max}$ was examined by subjecting the data to a two-way analysis of variance.

RESULTS

Table I presents the means and standard deviations for each variable for the age groups 17-25 and 26-35. Several subjects either declined to participate in certain aspects of the study or possessed contraindications to performing a maximal treadmill test. This accounts for the variability in sample size within each age group.

The 26-35 year old age group had a significantly higher body weight than the younger group. This was primarily the result of a greater body fat content (19.3 vs. 16.9% fat). This difference in body weight between groups was further reflected in the $\dot{V}O_{2max}$, where the older group was 8% lower ($p<0.01$) on a ml/kg·min basis (52.8 to 48.7) but did not differ statistically on a 1/min basis. The combined $\dot{V}O_{2max}$ was 51.6 ml/kg·min.

Although the mean plasma cholesterol level was not significantly different between the two groups, it tended to be higher for the older age group (178 ± 70 mg/dl) then for the younger group (158 ± 64 mg/dl). No significant differences were noted in systolic or diastolic blood pressures or percent smokers between age groups.

The prevalence of CHD risk factors is presented in Table II. Obesity (>20% and >25%), elevated blood cholesterol (>200 mg/dl) and cigarette smoking (>1.0 ≤1.5 packs/d) appeared to be the more predominant risk factors in both age groups. A significantly greater number of individuals in the older age group (46.5%) had body fat contents in excess of 20% than in the younger group (22.3%). Consistent with the above findings was the significantly larger percentage (27%) of the older age group with a $\dot{V}O_{2max}$ below 45 ml/kg·min compared to the young group (only 3.7%).

The 26-35 year old group also had a significantly greater percentage of individuals than the younger group with plasma cholesterol levels either between 200 and 250 mg/dl (36.0% vs. 22.1%) or greater than 250 mg/dl (10.1% vs. 4.1%).

No significant differences were found in the prevalence of elevated blood pressure between groups. This risk factor occurred in only 5% of the individuals studied. Similarly, no differences were noted in the incidence of abnormal ECG's, either at rest or after exercise, for the two age groups. Approximately 10% of the total sample tested had an abnormal ECG at rest of after exercise.

The incidence of ECG changes is presented in Table III. There was no significant difference in the incidence of any of the abnormalities between age groups. At

TABLE I. DESCRIPTIVE CHARACTERISTICS OF SUBJECTS BY AGE GROUP (Mean ± S.D.).

Variable	Age 17-25	26-35	Total
Physical Characteristics	248+	111	359
Age (yrs)	21.1 ± 1.1	28.8 ± 1.2*	23.6 ± 1.1
Height (cm)	175.2 ± 6.2	175.2 ± 7.6	175.2 ± 6.6
Weight (kg)	71.5 ± 9.0	77.2 ± 13.2*	73.0 ± 10.7
Body Composition	234	86	320
Percent Fat (%)	16.9 ± 4.8	19.3 ± 5.5*	17.4 ± 5.6
Fat Weight (kg)	12.1 ± 5.2	14.9 ± 6.5*	12.7 ± 6.1
Lean Body Mass (kg)	59.4 ± 5.6	62.3 ± 6.1*	60.3 ± 6.4
Physical Work capacity	215	85	300
HR max (BPM)	190.4 ± 6.8	188.5 ± 8.0	189.8 ± 7.1
$\dot{V}_E$ max BTPS (l/min)	144.5 ± 18.8	139.0 ± 19.9	142.9 ± 19.4
$\dot{V}O_2$ max (l/min)	3.75 ± 0.44	3.70 ± 0.46	3.74 ± 0.43
$\dot{V}O_2$ max (ml/kg·min)	52.8 ± 4.9	48.7 ± 5.6*	51.6 ± 5.4
Blood Pressure	248	111	359
Systolic	116 ± 13	117 ± 9	117 ± 12
Diastolic	67 ± 11	69 ± 8	68 ± 10
Cholesterol (mg/dl)	158 ± 64	178 ± 70	163 ± 68
Cigarette Smokers (%)	56.7	58.1	57.1

+ Number of Subjects
* p<0.01 between age groups

TABLE II. PREVALENCE OF CORONARY RISK FACTORS BY AGE GROUP.

Risk Factors	Prevalence (Percent) 17-15	25-35	Total
Obesity			
Percent Fat >20% ≤25%	15.0	30.2*	19.1
>25%	7.3	16.3*	9.7
Low Aerobic Capacity			
$\dot{V}O_2$max <40 ml/kg·min	0.0	8.2*	2.3
≥40 ≤45 ml/kg·min	3.7	18.8*	8.0
Blood Pressure			
≥200 ≤250 mg/dl	22.1	36.0*	25.6
>250 mg/dl	4.1	10.1*	6.5
Blood Pressure			
≥140/90 ≤160/95	3.6	6.3	4.5
>160/95	0.4	0.0	0.3
ECG Abnormalities			
At Rest	7.5	3.8	6.5
After Exercise	3.4	4.8	3.8
Cigarette Smoking			
≥1.0 ≤1.5 packs/d	24.1	40.5*	27.9
>1.5 packs/d	7.8	6.8	7.5

*p<0.01 between age groups

TABLE III. ELECTROCARDIOGRAPHIC FINDINGS.

	Percent Incidence (Number) By Age*		
	17-25	26-35	Total
At Rest	252*	104	356
T-Wave Inversion	2.0(5)	1.9(2)	2.0(7)
Right Axis Deviation	0.8(2)	1.0(1)	0.8(3)
Premature Ventricular Contraction	0.8(2)	1.0(1)	0.8(3)
First Degree A-V Block	2.3(6)	0(0)	1.7(6)
Second Degree A-V Block	0.3(1)	0(0)	0.3(1)
Right Bundle Branch Block	0.8(3)	0(0)	0.8(3)
After Exercise	207	84	291
Premature Ventricular Contraction	1.0(2)	1.2(1)	1.0(3)
ST-Junction Depression ($\geq$ 1 mm)	1.9(4)	3.6(3)	2.4(7)
Wolff-Parkinson White Syndrome	0.3(1)	0(0)	0.3(1)

* Number of subjects in parentheses.

rest, the major findings were T-wave inversion (2%) and first degree A-V block (1.7%). After exercise, 2.4% of the subjects had ST-segment depression of 1 mm or greater, indicating a positive stress test.

Table IV presents the mean data for percent body fat, plasma cholesterol, systolic and diastolic blood pressure, and percent smokers for four ranges of $\dot{V}O_{2max}$. Percent body fat was significantly lower as the range in $\dot{V}O_{2max}$ increased for both age groups. No differences were seen between age groups at any range of $\dot{V}O_{2max}$. There were no differences in plasma cholesterol among the $\dot{V}O_{2max}$ ranges for the 17-25 year old group. A significantly lower cholesterol was seen for the highest aerobic range (>55.0 ml/kg•min) compared to the lowest ($\leq$45.0 ml/kg•min) for the 26-35 year old group. Small but significant differences were also found between age groups for two of the fitness ranges ($\leq$45.0 and >50.0 <55.0 ml/kg•min).

There were no differences in systolic and diastolic blood pressures or in percent smokers among any of the ranges in $\dot{V}O_{2max}$, either within or between age groups.

DISCUSSION

Most studies relating to the incidence of CHD risk factors (8,18,19,35) and the influence of physical fitness on these factors (7,29) have consisted of middle-aged persons; information on young adults is limited. Available evidence suggests, however, that CHD risk factors can be identified early in life (13,37).

The data presented indicate the prevalence of these risk factors in a group of young active military personnel. The most predominant factors found were obesity, elevated blood cholesterol, and cigarette smoking. Obesity has been identified as one of the most prevalent health problems at all ages in the U.S. and has been shown to be a definite risk factor for development of CHD (32). Indeed, the prevalence of obesity in the present study and others (13,32) indicate it to be one of the most frequently identifiable risk factors. While no unified criterion exists as to what constitutes obesity, Behnke and Wilmore (2) have suggested that the threshold of obesity should be set at 20% body fat on assumptions of the lipid saturation of adipose tissue. The 28.8% prevalence of body fat content in excess of 20% (9.7% in excess of 25%) found herein would appear to be rather high. However, similarly high incidences of body fat content greater than 20% body weight have been reported for both younger (13,37) and older (7,22) age groups.

Plasma cholesterol has been shown to be an important risk factor, with available evidence suggesting a gradient of risk with increasing levels (18,35). The incidence for development of ischemic heart disease has been estimated to be 4.7 times greater in individuals

TABLE IV. DISTRIBUTION OF % BODY FAT, PLASMA CHOLESTEROL, SYSTOLIC AND DIASTOLIC BLOOD PRESSURE AND % SMOKERS BY AGE AND $\dot{V}O_{2max}$ ($\bar{x}$ ± S.D.).

	$\dot{V}O_2$max (ml/kg•min)			
	$\leq$45.0	>45.0 $\leq$50.0	>50.0 $\leq$55.0	>55.0
% Body Fat				
17-25 years old.†	15	47	80	73
	23.3 ± 1.3	19.7 ± 0.7*	15.9 ± 0.5*	14.6 ± 0.4*
26-35 years old.†	20	19	23	12
	25.2 ± 0.7	19.7 ± 1.2*	16.9 ± 0.8*	14.7 ± 1.4*
Cholesterol				
17-25 years old.†	12	47	72	61
	181 ± 12	179 ± 6	179 ± 4	173 ± 4
26-35 years old.†	17	17	21	11
	220 ± 14**	189 ± 11	199 ± 6**	187 ± 9*
Blood Pressure				
17-25 years old.†	13	48	80	71
	119.7 ± 2.9	117.1 ± 1.2	116.4 ± 1.2	117.2 ± 1.1
	69.1 ± 2.1	69.1 ± 1.0	69.3 ± 0.9	66.3 ± 0.9
26-35 years old.†	20	20	22	10
	119.4 ± 2.1	117.0 ± 1.6	115.1 ± 2.1	115.6 ± 1.8
	73.5 ± 1.6	69.5 ± 1.7	68.2 ± 1.3	69.4 ± 2.5
% Smokers				
17-25 years old.†	15	50	85	74
	67.0	52.0	51.8	59.5
26-35 years old.†	20	19	22	9
	60.0	52.6	63.6	66.7

† Number of subjects; *p<0.05, compared to lowest $\dot{V}O_2$max range within age groups; **p<0.05, compared between age groups.

with cholesterol values in excess of 250 mg/dl than in subjects with levels less than 200 mg/dl (20). In the present study, 32.1% of the total sample had levels greater than 200 mg/dl with 6.5% being greater than 250 mg/dl. These data fall in line with cholesterol data reported for various other age groups. Wilmore and McNamara (37) found in a group of 8-12 year olds an incidence of 19.8% with values in excess of 200 mg/dl. In an older military population (>35 years of age) Denniston *et al.* (8) reported incidences of nearly 45% for cholesterol levels greater than 200 mg/dl and 6% for those greater than 250 mg/dl. Similar incidences have also been shown in other older populations (18,20,35).

Extensive data from several prospective studies have demonstrated a significant relation between cigarette smoking and ischemic heart disease (18,35). Indeed, the data of Doyle *et al.* (10) showed a threefold increase in the incidence of myocardial infarction and death in smokers compared with nonsmokers. The high incidence of smokers (57%) found in the present study is similar to incidences reported for other military populations (4,8) and represents the most predominant risk factor in this group. Some evidence suggests that cigarette smoking decreases with age (35). However, the incidence of individuals smoking more than a pack/d increased in this study. While no conclusions can be drawn from such cross-sectional data, they do emphasize the cardiovascular risk of this factor in the military environment.

Elevated blood pressure is also well known to be associated with an increased risk of premature ischemic heart disease. Kannel *et al.* (17) have shown that individuals classified as hypertensive (≥160/95) died at more than twice the rate of normotensives (= 140/90). In considering abnormal elevations of pressures (≥140/90), a range which has been associated with increased morbidity and mortality (30), the incidence of abnormality (4.5%) was relatively low for the total sample reported herein. The incidence of abnormality using the same criteria is 41% in the older adult male population (17). A similar incidence was reported for an older (>35 years of age) military population (8). For the hypertensive category (≥160/195), only one subject (0.3%) fell within this range, while older male civilian (17) and military (8) populations reported incidences of nearly 18%.

The post-exercise finding of ischemic ST-segment depression, with none at rest, has been found to be highly predictive of ischemic heart disease (1,3). The incidence of ST-segment depression in epidemiological studies of the male population over 35 years of age has ranged from 9% (1) to 13.5% (31). Denniston *et al.* (9) reported incidences of 12.3% and 6.3% for non-commissioned and commissioned officers, respectfully, in a select military population over 35 years of age. Similar results were also reported for officers by Kowal *et al.* (22). The 2.4% prevalence of ST-segment depression seen herein would appear to be relatively low for this age group. However, the incidence of abnormal resting and exercise ECG's is considered rare in younger age groups. Wilmore and McNamara (37) found no evidence of ST-segment depression during exercise testing in a group of 95 boys 8-12 years old.

A number of studies have identified inadequate physical activity as a risk factor in CHD (7,12,29). In the present study, where cardiorespiratory fitness was directly determined, a relatively low incidence (2.3% with $\dot{V}O_{2max}$ less than 40 ml/kg·min) of low aerobic capacity was found. While this may be expected for a young group of infantry soldiers, the mean $\dot{V}O_{2max}$ (51.6 ml/kg·min) was similar to that reported by others for comparable age ranges (14,36).

In addition to being a significant risk factor in itself, physical activity has been shown to have a favorable influence on other risk factors. Physical training has been shown to reduce elevated blood pressure, blood cholesterol, and obesity (6). However, the data regarding the role of exercise in significantly reducing blood pressure and cholesterol levels is somewhat equivocal at present, as several well-controlled studies have failed to demonstrate changes with physical conditioning (16, 21,28). In an attempt to relate aerobic fitness and cardiovascular risk factors in the present study, they were compared at four ranges of $\dot{V}O_{2max}$. Only for percent body fat was there a demonstrable inverse relationship with aerobic power. In a similar cross-sectional study of military personnel, Brown *et al.* (4) found the relationship between fitness and CHD risk factors was most significant for the over-40 age group. Kowal *et al.* (22), however, found no relation between fitness level and the reduction of risk factors in a similar age group.

In addition to fitness and its possible influence on risk factors, many investigators are agreed that age has an important bearing on the development of ischemic heart disease (19,35). Several of the conventional risk factors, i.e. blood cholesterol, obesity, blood pressure and physical activity, are known to be age related. The significance in the prevalence of obesity, low aerobic capacity, and elevated blood cholesterol between the two age groups studied herein primarily reflects, therefore, the normal or expected differences in these variables with increasing age.

The substantial level of physical fitness found in this sample most likely reflects the military's emphasis on physical training. However, the relatively high incidences of obesity, elevated blood cholesterol, and particularly cigarette smoking are definitely of concern for this young age group. It must be kept in mind that this sample does not represent a random sample of the general population but, rather, is a relatively small group of military personnel. Therefore, the extrapolation of these observations to other populations must be done with caution. The study does provide, however, data on cardiovascular disease risk factors in an age group for which there has been only limited information.

ACKNOWLEDGEMENTS

The authors wish to express their sincere appreciation for the outstanding technical assistance provided by Robert Mello, Dan White, and Alice Stivanelli for body composition and oxygen uptake determinations, Cheryl Traver for ECG measurement, and Genevieve Farese for cholesterol determination. The authors are especially indebted to L. Howard Hartley for interpretation of the resting and exercise electrocardiograms.

Special thanks are also extended to Barbara Shults for the excellent preparation of the manuscript.

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